TITLE OF THE INVENTION

PROCESS MONITORING METHODS IN A PLASMA PROCESSING APPARATUS, MONITORING UNITS, AND A SAMPLE PROCESSING METHOD USING THE MONITORING UNITS

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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to methods of measuring potential differences and currents,

10   especially, to methods of measuring the potential difference or plasma current developed on the surface of a semiconductor wafer sample under its plasma status during semiconductor manufacturing processes when the semiconductor wafer is placed inside a plasma

15   reactor in order to surface-treat the wafer. Also, the present invention relates to an apparatus for monitoring processes in a plasma processing apparatus by use of the measured potential difference or plasma current, and to a sample processing method that uses

20   the process monitoring apparatus.

Related Background Art

In general, during the manufacture of semiconductors, semiconductor wafers need to be provided with various surface treatment processes such

25   as etching, and a plasma reactor that applies

electromagnetic waves to generate plasma is most commonly used as the surface processing apparatus. For such a plasma reactor, the electromagnetic waves and the plasma generate a strong electric field not only in the space of the plasma reactor, but also on the surface of the semiconductor wafer mounted on a processing table (sample mount). When the strong electric field is generated on the surface of the semiconductor wafer, the field strength will cause a potential difference on the surface of the semiconductor wafer, and if the potential difference exceeds the required value, the semiconductor wafer may be damaged. It is therefore important to measure the potential difference on the semiconductor wafer when processing its surface using the plasma reactor.

In this case, probing (hereinafter referred to as the first known method) is available as one of typical methods of measuring the electric field strength and potential differences occurring inside the plasma reactor. The first known method is intended to measure the electric field strength and potential differences inside the plasma reactor by inserting conductor probes into a plasma atmosphere and then after scanning with the probes, detecting the voltage-current characteristics thereof.

A method of measuring the potential of a
semiconductor wafer inside a plasma reactor
(hereinafter, this method is referred to as the second
known method) is also laid open on page 775 of a

5   Japanese-Version Preliminary Article Collection at the
46th Association Symposium on Applied Physics, held in
the spring of 1996. For the second known method, the
potential difference on the semiconductor wafer is
measured by searching with probes embedded directly in

10   a position on the semiconductor wafer (mounted on the
sample mount, namely, the semiconductor wafer mounting
table, inside the plasma reactor) where the potential
difference is estimated to occur, instead of searching
with probes embedded in the sample mount itself.

15   Since the first known method, which is intended to
measure the potential difference on the semiconductor
wafer inside the plasma reactor, is used to detect the
voltage-current characteristics of the conductor
probes by scanning in a plasma atmosphere, it is

20   necessary to collect detection output signals from the
conductor probes into an external apparatus by using
connection lead wires, and to provide the vacuum
chambers with connection lead wire relay terminals
because plasma is generated inside the vacuum chambers.

25   In addition, the total structure of the plasma reactor

is complex and this makes it impossible for the potential difference on the semiconductor wafer to be measured using a simplified means.

Furthermore, since the second known method, which is intended to measure the potential difference on the semiconductor wafer inside the plasma reactor, uses probes embedded in a sample mount on which the semiconductor wafer is to be mounted, it is necessary for the sample mount to be of special structure, but also difficult to process the surface of the semiconductor wafer on this sample mount after measuring the potential difference on the semiconductor wafer by use of the sample plate. In addition, the type of sample mount to be used differ between measurement of potential difference on the semiconductor wafer and the surface-treatment processing thereof, and this results in increased plasma reactor costs and, hence, an increased number of treatment processes.

SUMMARY OF THE INVENTION

The present invention allows for such a technical background, and one of its objects is to supply a potential difference and current measuring method that enables the DC potential difference on a target object

to be measured using a simplified means via a potential difference and current measuring portion of a simplified configuration.

Another object of the present invention is to supply a method that enables samples to be efficiently processed while processes are being monitored using an apparatus of a simplified configuration.

When a light-emitting diode or the like is left in a plasma-exposed atmosphere, the potential difference arising from the resulting flow of charged particles (ions and electrons) from the plasma will create the flow of an electric current into the light-emitting diode and activate it to emit light. The light emission intensity of the light-emitting diode has a constant correlation with the voltage and current of the diode. The present invention utilizes this property.

The present invention is characterized in that in a method of measuring the potential differences for plasma processing with a plasma processing apparatus that processes a sample by introducing a gas into vacuum chambers and generating plasma: a light-emitting portion is formed on a measurement-use sample, the potential difference generated according to the difference in the amount of plasma-incident charged

particle is detected,

a current flows into said light-emitting portion according to the potential difference that has been generated across said light-emitting portion,

5   the intensity of the light emitted from said light-emitting portion according to the particular level of said current is measured, and

the potential difference on said measurement-use sample according to the particular light intensity is

10   measured.

The present invention is also characterized in that in a method of measuring the plasma processing potential difference on the object to be plasma-processed by introducing a gas into vacuum chambers

15   and generating plasma:

a light-emitting portion is formed on said object to be plasma-processed,

the flow of charged particles from the plasma to the surface of said object is measured as the

20   intensity of the light emitted from said light-emitting portion according to the level of the current flowing thereinto, and

the amount of current flowing into said object according to the particular light intensity is

25   measured.

For example, antennas for acquiring charged particles from plasma to the terminals of the light-emitting portion are connected first. These antennas are then installed inside the plasma processing

5 apparatus or on the wafer and the light emission intensity of the light-emitting portion is measured. It is possible to measure the potential difference between any two positions by establishing the correlation expression between the pre-calculated

10 light emission intensity and voltage-current characteristics of the light-emitting portion and converting the light emission intensity into a voltage, or to measure the plasma current between any two positions by converting the light emission intensity

15 into a current using the above-mentioned expression.

To measure the plasma potential difference, the circuit resistance value of a light-emitting diode needs to be greater than an external circuit resistance including the plasma, or to measure the

20 plasma current, the circuit resistance value of the light-emitting diode needs to be smaller than the above-mentioned external circuit resistance value. This method requires only the window for measuring light intensity, and does not require lead wires or

25 lead wire lead-in terminals.

In order to fulfill the foregoing objects, a
potential difference measuring method based on the
present invention uses a potential difference and
current measuring portion equipped with one pair of

5   conductor antennas, a light-emitting portion connected
between the conductor antennas, and an AC voltage
bypass element connected in parallel to the light-
emitting portion, and has a means of
arranging/connecting the conductor antennas at/to the

10   potential measuring positions on the object to be
measured, and measuring the DC potential differences
at these potential measuring positions by detecting
the intensity of the resulting light output from the
light-emitting portion.

15   According to the means described above, after the
arrangement and connection of the conductor antennas
at/to the potential measuring positions on the object
to be measured, when DC potential differences exist at
these potential measuring positions, the light-

20   emitting portion or the light-emitting diodes will
emit light. The DC potential differences at the
potential measuring positions can therefore be
measured by visually detecting the emitted light
intensity from the unit containing the target object

25   (for example, from the exterior of the plasma

generating layer) through an optical unit such as a charge-coupled device (CCD) camera. Thus, it is unnecessary to provide connection lead wires intended to acquire detection output signals, or a sample mount in which conductor probes for detection are embedded.

In this case, since an AC voltage bypass element (preferably, a capacitor) is connected in parallel to the light-emitting portion, any AC potential differences between potential measuring positions are bypassed by the AC voltage bypass element and only the DC potential differences at the potential measuring positions can be measured.

The present invention also makes it possible to supply a highly efficient sample-processing method that uses a potential difference and current measuring portion of a simplified configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a total block diagram of ECR etching apparatus.

Figure 2 is a top view of the potential difference and current measuring unit described as an embodiment of the present invention.

Figure 3 is a cross-sectional view of the potential difference and current measuring unit

described as an embodiment of the present invention.

Figure 4 is a diagram showing the principles of the present invention.

Figure 5 is a diagram showing the relationship between the voltage applied to light-emitting diodes, and the intensity of the light emitted from the diodes.

Figure 6 is a diagram showing an example of application results on the present invention.

Figure 7 is a diagram showing an example of application results on the present invention.

Figure 8 is an another block diagram of the potential difference and current measuring unit of the present invention.

Figure 9 is a total block diagram of semiconductor processing equipment applying the potential difference and current measuring unit of the present invention.

Figure 10 is a flowchart intended to improve productivity by applying the potential difference and current measuring unit of the present invention to semiconductor processing.

Figure 11 is a flowchart intended to apply the potential difference and current measuring unit of the present invention to the optimization of semiconductor processing equipment.

Figure 12 is an another block diagram of a

potential difference measuring unit based on the present invention, and shows a potential difference and current measuring unit not having a capacitor.

Figure 13 is a total block diagram of ashing apparatus.

Figure 14 is an another block diagram of a potential difference measuring unit based on the present invention.

Figure 15 is an another block diagram of a potential difference measuring unit based on the present invention.

Figure 16 is an another block diagram of a potential difference measuring unit based on the present invention.

Figure 17 is an another block diagram of a potential difference measuring unit based on the present invention.

Figure 18 is an another block diagram of a potential difference measuring unit based on the present invention.

Figure 19 is an another block diagram of a potential difference measuring unit based on the present invention.

Figure 20 is an another block diagram of a potential difference measuring unit based on the

present invention.

Figure 21 is an another block diagram of a potential difference measuring unit based on the present invention.

5   Figure 22 is an another block diagram of a potential difference measuring unit based on the present invention.

Figure 23 is a diagram showing a method of observing light emission status in a potential
10   difference measuring unit based on the present invention.

Figure 24 is a diagram showing the installation location for a potential difference measuring unit based on the present invention.

15   Figure 25 is an another block diagram of a potential difference measuring unit based on the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

20   Embodiments of the present invention are described using figures.

A total block diagram of an ECR type of etching apparatus to which the invention applies is shown as Fig. 1. Microwaves are introduced from microwave power
25   supply 101 into vacuum chambers 104 via waveguide 102

and introducing window 103. Introducing window 103 is made of a material that transmits electromagnetic waves, such as quartz. Around vacuum chambers 104 are arranged electromagnets 107 and the strength of the

5   magnetic fields generated thereby is set so as to generate resonance with the frequency of the microwaves. For example, if the frequency is 2.45 GHz, the magnetic field strength is 875 Gauss. Wafer 105 (or plasma potential difference and current measuring

10 unit 200) is mounted on sample mount 108. High-frequency power supply 109 is connected to sample mount 108 in order to accelerate the flow of ions into the wafer. The Earth ring 114 against the high-frequency waves are provided around sample mount 108.

15   Also, in order to measure the light emission intensity of the light-emitting diodes mentioned later, the waveguide has window 112, through which an image of the wafer is monitored using a CCD (charge-coupled device) camera 110. Data that has been acquired by the

20 camera is processed by personal computer 111. In order to remove the light emitted from plasma 106, camera 110 has interference filter 113 adjusted to the light emission wavelength of the light-emitting diodes.

        Figure 2 is a top view of plasma potential

25 difference and current measuring unit 200 (an

embodiment of the present invention), and this
measuring unit has a potential difference and current
measuring portion formed on a measurement-use sample
of similar material and shape as those of the wafer

5   105 to undergo processing, and is mounted on sample
mount 108. Figure 3 is a cross-sectional view of
plasma potential difference and current measuring unit
200.

Plasma potential difference and current measuring

10   unit 200 further has oxide film 205 deposited on its
silicon substrate 204, and light-emitting diode (LED)
201 is mounted on the oxide film. Aluminum antennas
203 are connected at both ends of the LED via
insulated conductors. The plasma reactor used for

15   etching ranges from 0.5 to 5.0 mA/cm^2 in saturated ion
current density. Since the turn-on current (on-
emission energizing current) of LED 201 is only about
1 mA, the surface areas of the conductor antennas can
be set to overstep the range from 0.2 to 2.0 cm^2. The

20   antenna areas can usually be adjusted according to the
particular plasma density.

In this measuring unit, as shown in Fig. 2, one to
five light-emitting diodes (LED1 to LED5) are
connected in series and independent antennas are

25   connected at both ends of each LED. In this way, the

starting threshold voltage of light emission from each
LED is varied to improve measurement accuracy. Each
LED has parallel-connected capacitor 202 as a filter
for removing AC voltage components. The appropriate

5   value of the capacitor is about one microfarad when
the frequency of high-frequency power supply 109 is
800 kHz. Usually, however, it suffices just to change
the value according to the particular frequency. Also,
since this example assumes that the potential in the

10   center of the wafer is greater than that developed
around the wafer, connection polarity is given so that
each diode emits light when potentials are distributed
that way. Only when one LED is present, is a reverse
polarized diode also connected in parallel. Thus,

15   detection is possible when the potential around the
wafer is higher.

Figure 4 shows the distribution of the potentials
developed on wafer 105 (or plasma potential difference
and current measuring unit 200) in the etching

20   apparatus shown in Fig. 1. The nonuniformity of
potentials on the wafer is caused by the nonuniformity
of plasma density and/or the nonuniformity in the
distribution of currents from high-frequency power
supply 109. In Fig. 4A, the potential in center point

25   A of the wafer is higher than the potential at edge

point B of that wafer by ΔVdc. Also, the high-frequency voltage components of high-frequency power supply 109 overlap on the wafer and as shown in Fig. 4B, the potential between points A and B changes with time. Even if ΔVdc is zero, since each LED emits light with the above-mentioned high-frequency components, capacitor 202 is connected in parallel to LED 201 to ensure that only the DC component of ΔVdc is measured. Therefore, when the measuring unit shown in Fig. 2 is installed under the plasma status, the LED will emit light according to ΔVdc.

The relationship between the voltage applied to a series-connected LED and its light emission intensity is represented in Fig. 5, wherein LED1 to LED5 are the identification numbers of the series-connected diodes. These diodes emit red light, and the light-emission starting threshold voltage of one such diode is 1.5 V. When one to five diodes are connected in series, therefore, the respective light-emission threshold voltages are 1.5 V, 3.0 V, 4.5 V, 6.0 V, and 7.5 V.

Figure 6 shows the LED light-emission intensity data measurements with camera 110 that were obtained under the configuration where the plasma potential difference and current measuring unit 200 shown in Fig. 2 was installed in the etching apparatus of Fig. 1.

The horizontal axis denotes time, and the output of high-frequency power supply 109 was changed in steps from 10 W to 70 W with time. Light-emission intensity data that was obtained using three connected LEDs, and same data that was obtained using five connected LEDs are shown as examples in Fig. 6. It can be seen from this figure that when the three connected LEDs started emitting light at 20 W, ΔVdc exceeded 4.5 V, and that when the five connected LEDs started emitting light at 50 W, ΔVdc exceeded 7.5 V.

The measurement results on the relationship between high-frequency power and ΔVdc that were obtained using the above-mentioned method are shown in Fig. 7. The gas was a combination of 74-sccm chlorine and 6-sccm oxygen, and the gas pressure was 0.4 Pa. Also, the output of microwave power supply 101 was 400 W. These are etching parameters relating to the poly-silicon used for a semiconductor device.

Since the potential difference (ΔVdc) occurring on the wafer placed in plasma is a quantity related to the insulation breakdown of the gate oxide film on the transistor processed on that wafer, it is important to measure ΔVdc. When an etching apparatus is developed or etching parameters are determined, it is necessary not only that an etching rate and other parameters

relating to characteristics be appropriate, but also that the gate oxide film be free from insulation breakdown.

In the case of prior art, it is necessary that: during the measurement of a potential difference using the probe-embedded electrodes described in the examples of known methods, an apparatus be designed or etching parameters be determined so as to minimize the potential difference, and then the electrodes be replaced with the normal sample mount to etch the sample.

In the present invention, since the unit for measuring ΔVdc, namely, plasma potential difference and current measuring unit 200 has the same shape as that of a wafer, it is possible to measure ΔVdc without performing any modifications on the etching apparatus, and to etch semiconductor devices just by changing wafers after determining parameters for a sufficiently small value of ΔVdc. In other words, it is possible to reduce the processing time and to analyze etching characteristics, and measure the potential difference inside the wafer, with exactly the same apparatus configuration.

In the embodiment described above, although the antennas at both ends of each LED are arranged in the

center of and around the wafer, these antennas can be moved according to the desired potential difference measurement position on the wafer.

Also, the light emission intensity detected by
5   camera depends on factors such as the camera-to-LED distance and the transmittance of light of the window material. The absolute potential difference value can therefore be obtained by measuring the above-mentioned distance and transmittance and calibrating the
10   detection portion of the camera. Even if the calibration is not conducted, the relative magnitude of the potential difference inside the wafer can be judged from the light emission intensity.

Since a distribution curve of the potentials
15   developed on the wafer does not always have a humped middle as shown in Fig. 4, the polarity of the potentials can be judged by mounting one set of forward- and reverse-polarized LEDs in connected form on the wafer.

20   In Fig. 2, LEDs 201 and capacitors 202 can be shielded with polyimide or the like, as required, and thus the LEDs and the capacitors can be protected from plasma-induced damage.

The potentials on the wafer can also be measured
25   together with their AC components by removing

capacitors 202. The number of LEDs to be connected in series can be adjusted (or can be used blue and other diodes different in light emission threshold voltage) according to the particular magnitude of ΔVdc.

5   Camera 110 for measuring light emission intensity can be installed inside vacuum chamber 104 provided with the appropriate electromagnetic interference countermeasures, and the light-receiving portion can be equipped with an optical fiber. In Fig. 8A, light-

10   emitting circuit 801 is inserted between antennas 203A and 203B, and capacitor 202 is connected in parallel to light-emitting circuit 801 to remove AC components. When a potential difference occurs between antennas 203A and 203B, since the light-emitting circuit emits

15   light according to the particular potential difference, this value can be identified by closely observing the quantity of light which has been emitted. To remove AC components, coil 802 can be connected in series to light-emitting circuit 801, instead of connecting

20   capacitor 202 in parallel to light-emitting circuit 801. The light-emitting circuit here refers to a circuit that includes light-emitting diodes 201 or so-called miniature lamps whose resistance values change according to the voltage applied across the circuit,

25   or refers to a laser, such as a semiconductor laser,

that includes light-emitting elements. Various embodiments of this light-emitting circuit are described later. Although light-emitting circuit 801 that includes light-emitting elements is described

5 here, a unit for generating those sound waves or electromagnetic waves (such as ultraviolet rays, infrared rays, or X-rays) that change in intensity according to the voltage applied across the circuit can be used, instead of light-emitting elements. When

10 such a unit is used, however, it is, of course, necessary to use a sensor or filter as well, instead of camera 110 or interference filter 113, that can detect those sound wave signals or electromagnetic wave signals. It is important to provide a means of

15 generating some type of physical quantity according to either the voltage applied across the circuit, or the current corresponding to the voltage, and a means of detecting the physical quantity at a position far from the means mentioned above.

20 Next, a method of using plasma potential difference and current measuring unit 200 to manufacture semiconductors is described below. An example of a semiconductor manufacturing equipment configuration is shown in Fig. 9. This configuration

25 includes, more specifically, an etching apparatus, a

CVD apparatus, etc.

The semiconductor manufacturing equipment in Fig. 9 has processing chamber 901, second processing chamber 902, wafer transport robot 903, loading lock chamber 904, unloading lock chamber 905, loader 906, and stocker 907. Stocker 907 contains cassettes 908 and dummy cassette 909. When a wafer is processed in processing chamber 901, wafer 105 within cassette 908 under almost atmospheric conditions is transported to loading lock chamber 904, which is also under almost atmospheric conditions, by loader 906, and then the loading lock chamber is closed. After loading lock chamber 904 has been decompressed to a suitable pressure, wafer transport robot 903 transports wafer 105 to processing chamber 901, where the wafer is then provided with appropriate processing. After being processed, wafer 105 is transported to unloading lock chamber 905 by wafer transport robot 903. After the internal pressure of unloading lock chamber 905 has been increased nearly to an atmospheric pressure, wafer 105 is returned to cassette 908 by loader 906. Such processes are usually repeated.

Next, a method of using plasma potential difference and current measuring unit 200 to process wafers is described in Fig. 10. Wafers 105 usually

undergo processing in processing chambers 901 and 902 (S1000). When processing parameters are checked periodically or non-periodically, plasma potential difference and current measuring unit 200 that has been placed in dummy cassette 909 beforehand is transported to the processing chambers, where the processing parameters can then be checked (S1002). That is to say, when processing parameters are checked, plasma potential difference and current measuring unit 200 that has been placed in dummy cassette 909 beforehand is transported to loading lock chamber 904 by loader 906 and then transported to processing chamber 901 by wafer transport robot 903. After this, plasma potential difference and current measuring unit 200 undergoes processing with predetermined parameters and the light emission status at this time is monitored to confirm the presence/absence of an abnormality and detect its level (S1004).

When no abnormality is detected, potential difference and current measuring unit 200 is removed using wafer transport robot 903, then placed in unloading lock chamber 905, and placed in dummy cassette 909 by loader 906 to restart semiconductor processing (S1000).

If abnormality is detected, the processing

chambers are maintained in a vacuum state as far as possible and the processing apparatus is checked and provided with countermeasures (S1006). After the countermeasures have been undertaken, plasma potential difference and current measuring unit 200 undergoes processing with predetermined parameters once again and light emission status is monitored (S1008) to confirm the presence/absence of an abnormality and detect its level (S1010).

At this time, when no abnormality is detected, potential difference and current measuring unit 200 is removed using wafer transport robot 903, then placed in unloading lock chamber 905, and placed in dummy cassette 909 by loader 906 to restart semiconductor processing (S1000). If abnormality is detected again at this time, potential difference and current measuring unit 200 is removed using wafer transport robot 903, then placed in unloading lock chamber 905, and placed in dummy cassette 909 by loader 906. After this, the processing chambers are exposed to the atmosphere and necessary processing takes place (S1012). The necessary processing here refers more specifically to replacement of consumable parts and removal of sticking film from the various sections of the processing chambers by use of substances such as

an organic solvent.

After these processes have been performed, the processing chambers are placed in a vacuum state once again to enable semiconductor processing. At this time, semiconductor processing is not started immediately. Instead, it is started only after the fact that processing chamber 901 has returned to normal is confirmed using potential difference and current measuring unit 200 (S1014 to S1016). If abnormality is detected during this process, processing chamber 901 or the entire semiconductor manufacturing equipment requires rechecking and then the maintenance processes described above and/or more extensive maintenance processes are to be performed.

Processing parameters relating to the potential difference and current measuring unit 200 of the present invention do not always need to match the semiconductor processing parameters. Given the same parameters, whether the parameters are being properly maintained is to be judged. However, the use of the parameters enables easy detection of abnormality, although these parameters differ from actual processing parameters, makes it possible to estimate beforehand any abnormal states that slightly change with the progress of time. Since these parameters

differ from actual processing parameters,
semiconductor processing does not always need to be
stopped, even if abnormality is detected. If
abnormality is detected under these parameters,

5   however, after semiconductor processing has been
restarted, the equipment status monitoring time is to
be made shorter than usual, by using the potential
difference and current measuring unit of the present
invention once again. This maintains equipment

10   availability and prevents the processed wafer from
being wasted.

       In the above-described embodiment, although
atmospheric cassettes are used for descriptive reasons,
vacuum cassettes can also be used instead.

15   Next, a method of using potential difference and
current measuring unit 200 in Fig. 11 to develop
processing unit 901 or etching processes is described
below. In this case, the potential difference and
current measuring unit is to be inserted into the

20   semiconductor manufacturing equipment to be developed,
for example, the etching apparatus shown in Fig. 1.

       For example, to optimize the height of sample
mount 108 for reduced potential difference inside the
wafer, it is necessary first to keep constant the

25   output power of the microwave power supply for

generating plasma, the output power of the high-
frequency power supply for applying a bias voltage to
the wafer, the internal pressures of the processing
chambers, the flow rate of the gas to be introduced
into the processing chambers, and other parameters,
and then to mount potential difference and current
measuring unit 200 on sample mount 108 and observe
light emission status. Next, only the height of the
sample mount is to be changed and light emission
status is to be observed again (S1100). Parameters
that generate an insignificant potential difference
inside the wafer can be found by repeating the above
experiments and examining the relationship between the
height of the sample mount and light emission status.
This method can be used only by inserting the
potential difference and current measuring unit,
instead of wafer 105, and does not require special
electrodes. Also, since this method enables the
quantity of light (namely, the potential difference)
to be immediately determined, actual processing can be
executed using wafer 105 before or after measurement,
and spectral analyses on the status of light emission
from plasma 106 can be easily conducted during, before,
or after measurement. That is to say, the height of
sample mount 108, the potential difference inside the

wafer, the plasma status at the particular time, and wafer processing results can be obtained for one set of parameters, and as a result, the configuration of the equipment can be optimized in various terms (S1102 to S1108). Although the height of sample mount 108 is taken as an example in the description made above, this method is also valid for optimizing factors such as the size of the sample mount, the position of the gas introducing port, and the size and position of earth ring 114.

In addition, this method is valid for optimizing not only the hardware-like configuration of the equipment, but also the type of processing gas, pressure, magnetic fields, the output power and frequency of the microwave power supply, the output power and frequency of the high-frequency power supply, and other various processing parameters (S1110 to S1116).

The etching apparatus shown in Fig. 1 is an example of reaction chamber 901.

Figure 12 is a block diagram of the potential difference and current measuring unit 200 shown as another embodiment of the present invention the in the case that a bias voltage is not applied. The measuring unit configuration in Fig. 12 differs from that of Fig.

2 in that capacitor 202 for removing AC components is
not provided. When no bias voltage is applied, AC
components can be ignored, and configurations without
capacitor 202 usually pose no problems. As a matter of

5   fact, for a CVD or ashing unit, no bias voltage is
applied occasionally, even during plasma processing.

An example of an ashing unit not requiring the
application of a bias is shown in Fig. 13. Although
the configuration in Fig. 13 is similar to that of Fig.

10   1, high-frequency power supply 109 and earth ring 114
are absent in the configuration in Fig. 13. The type
of gas used to remove resist is an argon gas, an
oxygen gas, or the like. When the potential difference
and current measuring unit in Fig. 12 is actually used,

15   this measuring unit is introduced into a unit such as
the ashing unit mentioned above.

In the potential difference and current measuring
unit 200 of the present invention, one of the two
antennas can also be routed through a circuit

20   substrate. Modified versions of the potential
difference and current measuring unit shown in Fig. 2
or 12 are shown in Fig. 14. In this invention, one
terminal of light-emitting diode (1401) is
characterized in that it is routed through substrate

25   204. In general semiconductor manufacturing processes,

the potential of the gate with respect to that of the
substrate is usually picked up as a problem. In the
configuration described above, however, the voltages
of the substrate and gate can be measured. Also, in
5   this unit configuration, antenna 203 not routed
through the substrate is installed in three places at
different distances from the center of the wafer. Thus,
the potential difference between antenna 203 and
silicon substrate 204 can be detected.

10   In addition, haircomb-shaped antenna can also be
used instead. The potential difference and current
measuring member shown in Figs. 15A and 15B is
composed of two LEDs 201 connected in parallel in
opposite directions between haircomb-shaped antenna
15   1501 and antenna 203, and capacitor 202 connected in
parallel to the LEDs. The measuring member shown in
Figs. 15A and 15B is located on and connected to
insulating film 205 with which the surface of silicon
substrate 204 is covered. In this case, haircomb-
20   shaped antenna 1501 is formed using resist 1502
processed in line-and-space form on conductor antenna
203 positioned on insulating film 205. The pattern of
the line-and-space form on resist 1502 is formed by
lithography during semiconductor manufacturing
25   processes, and the sizes of the line and space are

very small (several microns or less). Modification of antenna 203 into structure such as that of haircomb-shaped antenna 1501 enables the measurement of the DC potential difference in the microstructure due to a

5   phenomenon generally called "electron shading". Since the flow of ions into silicon substrate 204 under a plasma state is accelerated, these ions enter silicon substrate 204 almost vertically. In the meantime, electrons, because of their small mass, are great in

10   random-oriented velocity due to heat and therefore flow from random directions to silicon substrate 204.

For this reason, when resist 1502 with a microstructured pattern consisting of very small grooves and holes less than several microns in size is

15   present on silicon substrate 204, although a large majority of ions arrive at the bottom of the microstructured pattern, a large majority of electrons cannot reach the bottom. As a result, the bottom of its microstructured pattern is charged positively and

20   the walls of its microstructured pattern is charged negatively, this phenomenon is called "electron shading". During semiconductor device processing, the bottom of the microstructured pattern is usually connected to the gate oxide film, with the result that

25   since the gate is charged to cause insulation

breakdown, the magnitude of electron shading needs to
be measured.

Haircomb-shaped antenna 1501 shown in Figs. 15A
and 15B has its silicon substrate 204 charged
positively by electron shading, and thereby, a DC
potential difference occurs between haircomb-shaped
antenna 1501 and antenna 203. One of two LEDs 201,
therefore, emits light and the electron shading level
can be measured from the intensity of the light.
During the measurement of the electron shading level,
it is preferable that the haircomb-shaped antenna 1501
and antenna 203 connected between two LEDs 201 should
be arranged close to one another so as to avoid the
overlapping of DC potential differences between
positions. Also, measurements under the status that
electron shading and the DC potential difference on
the surface of silicon substrate 204 overlap can be
performed by spacing haircomb-shaped antenna 1501 and
antenna 203.

The value of the current flowing into LEDs 201 can
be obtained by arranging haircomb-shaped antenna 1501
and planar antenna 203 close to one another and
examining the intensity of the light emitted from LEDs
201. The value of the current flowing into LEDs 201 is
a quantity determined by the structure of haircomb-

shaped antenna 1501 and the ion current density of plasma 106. Since the structure of haircomb-shaped antenna 1501 is known, the ion current density can be calculated by examining the amount of light emitted

5   within this measuring unit.

If antenna 203, after being made thicker than antenna 1501, is exposed to plasma and both antennas 203 and 1501 are etched, the light emitted from LEDs 201 can be observed while antenna 1501 remains. Once

10   antenna 1501 has been etched, however, the current concentration area will decrease and LEDs 201 will stop emitting light. The etching rate can therefore be measured from the light emission duration of LEDs 201 and the thickness of antenna 1501. Modification of the

15   pattern on resist 1502 enables the measurement of an etching rate dependent on the new pattern, for example, a resist pattern with a new groove width or with a plurality of holes.

Next, a method of improving the uniformity of the

20   internal etching rates for the wafer surface by use of this measuring unit is described below. During the development of an etching apparatus or the determination of etching parameters, the uniformity of etching rates is required to satisfy predetermined

25   standards for the entire wafer surface. Although

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conventional methods usually are by using interference

to measure etching rates immediately, it is very

difficult to observe the rates in a plurality of

sections immediately at the same time for reasons such

5   as the limited installation position for a

spectroscope. Also, when complex patterns exist,

simultaneous observation of etching rates is not easy

since it requires sophisticated calculation of

diffraction with high accuracy. Unlike such

10   conventional methods, the method described below is a

very simple technique since it only requires that the

above-mentioned measuring unit should be installed in

multiple places on the wafer and that the light

emitted from light-emitting circuit 801 should be

15   observed during etching.

The requirement that the uniformity of flat areas

in etching rate over the entire wafer surface should

be high means the requirement that fluctuations in the

light emission duration of light-emitting circuit 801

20   should be insignificant. Accordingly, in the plasma

etching apparatus of Fig. 1, when fluctuations in the

light emission duration of light-emitting circuit 801

are measured with each etching process under different

settings of parameters such as the flow rate of the

25   gas to be introduced during etching, if the measured

fluctuations are insignificant, this means that the
etching rates for the flat areas are uniform over the
entire wafer surface.

An antenna with patterns can be easily constructed
by resting a micropatterned insulating material on the
conductor portion of the antenna. This insulating
material is, for example, the J5022-11 capillary plate
manufactured by Hamamatsu Photonix Corp. This
capillary plate has a plurality of holes 10 microns
across and 400 microns deep. For actual semiconductors,
problems usually occur when areas about one micron or
less in size undergo processing. However, according to
Reference [1] below, it is known that when the sizes
of the patterns are sufficiently smaller than typical
sizes such as an average free stroke and a sheathing
thickness, provided that the patterns are analogous,
the equality in absolute size is not mandatory. That
is to say, the use of the above-mentioned capillary
plate or its processed or similar product enables the
situation of the order of one micron to be easily
simulated without using lithography or the like.

Reference [1]: N, Mise et al., "Proceedings of the
5th International Symposium on Plasma Process-Induced
Damage", p. 46, 2000

Next, energy control based on the present

invention is described. A unit that has meshwork 1602
with battery 1601 connected to the front of antenna
203 and measures the energy of the charged particles
entering the antenna, is shown as an embodiment in

5   Figs. 16A and 16B. A top view of the LED mounted on
the unit is shown as Fig. 16A, and a longitudinal
section of the LED is shown as Fig. 16B. The battery
is connected from hole 1603 of insulating film 205 to
silicon substrate 204. The other terminal of the

10   element 801 is also connected to the substrate 204
through hole 1604. When a voltage is applied to
meshwork 1602, repulsive force is given to ions and
electrons according to the particular direction and
magnitude of the application and as a result, only

15   ions whose energy is greater than the applied voltage
arrive at antenna 203. Thus, the number of charged
particles having a predetermined energy level can be
measured from the intensity of the emitted light and
the voltage of battery 1601. In Fig. 16, the

20   distribution of energy can also be measured by
installing multiple antennas equipped with batteries
1602 of different voltages.

Next, another embodiment of the present invention
is described using Fig. 17. This figure shows an

25   example of measurement under different surface area

settings of antenna 203. In this measuring method, a
sufficient current for activating the LED is required
for the measurement of its light emission intensity.
The upper limit of the current is a value determined
5   by the antenna area and the density of the plasma.
Even when a sufficient current is supplied, if the
potential difference across the LED is too low, its
light emission intensity is reduced by being limited
according to the applied voltage. Whether the light
10   emission intensity of the LED is limited by the
voltage or by the current is not univocally determined
since the above depends on the current-voltage
characteristics of the LED, the magnitude of the
potential difference on the wafer, the size of the
15   antenna, the density of the plasma, and other factors.
Although the surface area of the antenna needs to be
adjusted to find the region where the light emission
intensity can be measured, a wide range of currents
can be measured at the same time by providing
20   beforehand, as shown in Fig. 17, a plurality of LEDs
201 connected to antennas 203 of different surface
areas.

Figure 18 is another block diagram of on-wafer
potential difference measuring unit 200, another
25   embodiment of the present invention. Figures 18A and

18B are an enlarged top view and enlarged longitudinal
section of this measuring unit. In this embodiment,
measuring unit 200 uses thin oxide films as its light-
emitting elements. On silicon substrate 204 is

5   deposited an insulating layer 205, and thin gate oxide
films 1801 are provided as part thereof. Antenna 1802
made of poly-silicon or the like, is connected to gate
oxide films 1801. The thin oxide films emit light with
a sufficient supply of current and can therefore be

10   used similarly to LEDs 201. Since this unit
configuration is close to the configuration of a more
practical semiconductor wafer processing apparatus,
more accurate data measurements can also be obtained.

In the configuration of Fig. 18, a plurality of

15   light-emitting elements different in antenna surface
area are arranged on a wafer. Although only one set of
light-emitting elements are shown in the figure, it is
possible to arrange multiple sets over the entire
wafer surface and measure the distribution of energy.

20   Although intended to measure the potential difference
between antenna 1802 and silicon substrate 204, this
configuration can also be varied to measure the
potential differences between any other two positions.

In addition, since the LEDs are made of silicon,

25   not a compound semiconductor, they do not pose

problems associated with pollution. Furthermore,
during the manufacture of semiconductor devices using
a silicon substrate, light-emitting circuit 801 can be
formed in, for example, a scribe area or an area not
5   to be used as the semiconductor device at the edge of
a wafer, by forming LEDs by use of silicon. The
formation of light-emitting circuit 801 in such areas
is, in turn, effective for avoiding a decrease. in the
number of semiconductor devices which can be obtained
10   from one wafer. Furthermore, the use of this wafer
makes it possible to measure the potential difference
on the wafer surface under a plasma-exposed status and
the degree of damage of the gate oxide film while
creating devices. In short, it is possible to evaluate
15   the status of the plasma apparatus and the processing
parameters immediately and to estimate a device
manufacturing yield.

Next, an embodiment of light-emitting circuit 801
is shown in Fig. 19. In this embodiment, two circuits
20   are connected in parallel between antenna 203. The
first circuit consists of directly connected light-
emitting element 1901 and Zener diode Z1s, another
Zener diode Z1p connected in parallel to the 1901 -
Z1s connection, and diode D1 connected to diode Z1p.
25   The Z1s and the Z1p are polarized in a forward

direction, and the D1 is polarized in the reverse

direction to that of the Z1s. The voltage at which a

current abruptly begins to flow when a reverse voltage

is applied to the Zener diodes, is taken as VZ. In

5   this case, Zener diodes Z1s and Z1p are selected so

that the absolute threshold voltage VZ1p of the Zener

diode Z1p is greater than the absolute threshold

voltage VZ1s of the Zener diode Z1s. The second

circuit, which consists of the same elements as those

10   of the first circuit, has all its polarized components

reversed with respect to the polarized components of

the first circuit. In this case as well, Zener diodes

Z2s and Z2p are selected so that the absolute

threshold voltage value VZ2p of the Zener diode Z2p is

15   greater than the absolute threshold voltage value VZ2s

of the Zener diode Z2s. Light-emitting element L1 is

an element not having polarity, and L1 is, for example,

an element that emits light when activated by the

current flowing into the filament of tungsten.

20   The conditions where light-emitting element L1

emits light under the light-emitting circuit

composition shown in Fig. 19 are described below.

Since L1 and D1 are connected in series, it can be

seen that at least if $\Delta V = VA-VB > 0$ holds, does L1

25   emit light. However, if potential difference ΔV

between A and B is smaller than the threshold value of diode D1, namely, if $\Delta V < VD1$, no current flows into L1 because of the effects of diode D1, and this also applies in the case of $\Delta V < VD1 + VZ1s$, even when the potential difference increases. The reason why no current flows into L1 is that Zener diode Z1s does not yield. When the potential difference further increases ($\Delta V > VD1 + VZ1s$), Zener diode Z1s yields and a current begins to flow into L1. When potential difference ΔV increases more significantly (namely, $\Delta V > VD1 + VZ1p$), Zener diode Z1p also yields. Therefore, even when potential difference ΔV increases in the range of $\Delta V > VD1 + VZ1p$, the voltage between L1 and Z1s is maintained at a constant value of VD1+VZ1p. This means that Zener diode Z1p protects the circuit by preventing an overvoltage from being applied across light-emitting element L1 or an overcurrent from flowing into L1. Accordingly, ΔV and the light emission intensity of L1 directly vary when VD1+VZ1p < ΔV < VD1+VZ2p. When ΔV < VD1+VZ2p, however, the light emission intensity is kept constant, irrespective of ΔV.

When a reverse voltage is applied, only light-emitting element L2 emits light and L1 and L2 do not emit light simultaneously.

Consider the case that more specifically, the HZ6A1 Zener diodes, manufactured by Hitachi, Ltd., are used as Zener diodes Z1s and Z2s, the HZ7A1 Zener diodes, manufactured by Hitachi, Ltd., as Zener diodes Z1p and Z2p, and the HSK110 diodes, manufactured by Hitachi, Ltd., as diodes D1 and D2. According to the Hitachi Databook issued in September 1992, the yield voltages of the HZ6A1 and HZ7A1 are 5.2 V and -6.3 V, respectively, and the threshold voltage value of the HSK110 is 0.8 V. At this time, when potential VA of antenna A becomes 6.0 V higher than potential VB of antenna B, light-emitting element L1 emits light. When the difference between VA and VB is smaller than 7.1 V, the light emission intensity of L1 changes according to the voltage applied thereto. When the difference between becomes equal to or greater than 7.1 V, the voltage applied to L1 discontinues changing and the light emission intensity becomes independent of the potential difference. When VA and VB are opposite in polarity, L2 emits light.

Diodes can also be used as alternatives for Zener diodes. In general, the threshold voltage values of diodes are about 1 V and do not change too significantly. For this reason, a plurality of diodes need to be connected in series to obtain threshold

values falling within the desired range.

A modified version of the embodiment in Fig. 19 is shown in Fig. 20. In this version, four circuits are connected in parallel between antennas 203A and 203B. The first circuit consists of light-emitting element L1, Zener diode Z1, and diode D1, which are all connected in series. The Z1 and the D1 are opposite in polarity. The second circuit is of the same composition as that of the first circuit, and has all its polarized components reversed with respect to the polarized components of the first circuit. The third circuit consists of Zener diodes Z1p and Z2p connected in series, which are reversed in polarity with respect to one another. The fourth circuit consists only of capacitor C.

The light-emission condition of L1 in such circuit composition can be expressed s VA-VB > VZ1s+VD1. The voltage applied to L1 at this time can be expressed as (VZ1p+VZD2p) + (VZ1s+VD1), and the present invention, as with the invention of Fig. 19, provides a light-emitting element circuit protection function.

In Figs. 19 and 20, when Zener diode Z1p (Z2p) connected in parallel to light-emitting element L1 (L2) is omitted, since the voltage applied to L1 (L2) is not limited, the light emission intensity and the

VA-VB difference directly vary in the light emission

range. Therefore, the potential difference between

antennas A and B in the entire light emission range

can be detected by measuring the light emission

5   intensity. In this case, however, the possible flow of

an overcurrent into light-emitting element L1 (L2) may

damage the L1 (L2).

In Figs. 19 and 20, when diode D2 is omitted, L2

emits light if VA-VB > VZD2. That is to say, both L1

10   and L2 emit light if VA-VB > VZD2 and VA-VB > VZ1+VD1.

At this time, the VA-VB range can be further limited

according to the light-emission conditions of L1 and

L2.

In Figs. 19 and 20, when Z1s (Z2s) is omitted, L1

15   and L2 emit light if VA-VB > VD1 and VB-VA > VD2,

respectively.

Next, protection circuit 3 is described using Fig.

21. When the fact of VA>VB is known, light-emitting

circuit composition can be simplified. For example,

20   the case in which Zener diode Z2p is omitted from the

invention of Fig. 20 is shown in Fig. 21. At this time,

when elements are selected so that 0 < VZ1+VD1 <

VZ2+VD2 < VZ3 holds, only L1 emits light under the

condition of VA-VB > VZ1+VD1, and both L1 and L2 emit

25   light under the condition of VZ1+VD1 < VA-VB < VZ2+VD2.

Also, since the maximum voltage applied to L1 (L2) is
VZ3+VZ1+VD1 (VZ3+VZ2+VD2), L1 (L2) is protected. It is
possible to measure VA-VB by observing the intensity
of the light emitted from L1 and L2.

5   The appropriate light-emitting circuit can be
formed by adjusting the number of elements or
combining them in the light-emitting circuits of Figs.
19, 20, and 21, as required. In Figs. 19, 20, and 21,
although the light-emission voltage is described
10   considering miniature lamps (or the like as the light-
emitting elements, LEDs and other elements that have
diode characteristics slightly change in threshold
voltage. The principles of operation, however, are as
described above. Also, when diodes are used as the
15   light-emitting elements, diode D1 or D2 in series with
respect to the elements in the embodiment of Figs. 19,
20, and 21 is to be polarized in the same direction.

Figure 22 shows a unit having directly connected
resistor 2201 to adjust the voltage applied to LED 201.
20   This circuit composition can be applied when the
potential difference on the wafer is too great.
Current I can be derived from the light emission
intensity of LED 201. Voltage V1 across the LED can be
derived from the current-voltage characteristics of
25   the LED, and voltage V2 across the resistor can be

derived from IxR. The developed potential can be derived from V1+V2. In this circuit composition, a wide range of voltages can be measured at the same time by connecting resistors 2201 (R1 and R2) of

5   different values to the respective LEDs 201.

Figure 22 is a circuit block diagram showing the fifth embodiment of the potential difference and current measuring portion used for potential difference measurement based on the present invention.

10   This figure shows another example of circuit composition intended to extend the range of the DC potential differences which can be measured using the potential difference and current measuring portion, and the resistance elements for limiting the flow of

15   current into LEDs 201 are connected in series.

As shown in Fig. 22, potential difference and current measuring unit 200 has resistance elements connected in series to a parallel-connected circuit consisting of LEDs 201 and capacitors 202. Since

20   resistance elements 2201 are connected, this prevents an overcurrent from flowing into LEDs 201, and the DC potential difference between conductor antennas 203A and 203B is voltage-divided into the terminal-to-terminal voltage of LEDs 201 and the terminal-to-

25   terminal voltage of resistance elements 2201. Thus,

the voltage applied to LEDs 201 can be reduced below the DC potential difference between conductor antennas 203A and 203B, and the range of the DC potential differences which can be measured using the potential

5　difference and current measuring portion can be correspondingly extended.

And in this case as well, since the light emitted from LEDs 201 can be detected visually or through a CCD camera or the like, separate connection lead wires

10　or probes are not required for the acquisition of the detection output signals.

Next, an observing method different from the above-described method of observing light-emitting element 103 is described. In such etching apparatus as

15　shown in Fig. 23, measurement hole 2301 for a radiation temperature gauge is usually provided on sample mount 108 in order to measure the temperature of silicon substrate 204. If no such hole is provided, sample mount 108 needs to be provided with hole 2301

20　for observing substrate 204. The intensity of light on substrate 204 can be observed using hole 2301 provided on the surface of sample mount 108. At this time, when the appropriate light-emitting circuit 801 is selected so that the light emitted from light-emitting circuit

25　801 passes through substrate 204, this substrate can

be observed from the reverse side without ever having
to provide the substrate with a hole. Similarly to the
case that the light emission status of light-emitting
circuit 801 is observed from the surface of substrate

5   204, camera 2302, an interference filter, a personal
computer, and/or optical fibers are to be used as
required.

Silicon, for example, has the property that it
transmits light whose wavelength is about 1.3 microns

10   or more. When substrate 204 is composed principally of
silicon, therefore, the use of the L1450-35C LED
having a wavelength of 1,450 nm makes it possible for
the emitted light on the surface of substrate 204 to
be observed from the reverse side of this substrate

15   without ever having to provide it with a hole. Such
circuit composition occasionally makes it unnecessary
to provide observation window 112.

The potential difference and current measuring
unit of the present invention can be installed in

20   various places. More specifically, the packaging of
the potential difference and current measuring unit
when mounted on an insulating object enables this
package to be installed in any position and in any
number of places. This package can also be installed

25   on the inner wall of semiconductor manufacturing

equipment to observe the status of this inner wall.

The package usually is also permitted to be installed

in an area not directly exposed to the effects of the

plasma. This area is, for example, the side of sample

5   mount 108, the wall surface of the reaction chamber

facing the sample mount, or a position (say, 2401)

directly above the vacuum-exhaust pump for the

reaction chamber. This purpose is to interrupt wafer

processing immediately on detection of an unusual

10   state during plasma monitoring and then provide

corrective measures in order to return the plasma to a

normal state. These measures refer to, for example,

exposing the reaction chamber to the atmosphere and

cleaning the wall of the reaction chamber and the flow

15   channel of the exhaust system using an organic solvent

or the like. Also, the potential difference between

any two points can be measured using a package

installed on the inner wall (for example, position

2402) of waveguide 102.

20   Basically, the antennas are formed using

conductors. For minimum metal pollution, however,

impurity-doped polycrystal silicon or a light metal

(such as aluminum) or highly electroconductive carbon

should be used as the antenna material.

25   LEDs are usually made of a compound semiconductor

such as gallium nitride (GaN) or AlGaN, but if such LEDs are inserted in externally exposed form into silicon-based semiconductor manufacturing equipment, metal pollution will result. To avoid this problem,

5   the necessary section should be shielded with a suitable material which enables emitted light to be observed. Examples of this material include silicon oxide, plastic resin, and so on.

Next, an example of a GaAs light-emitting element

10 is shown using Fig. 25. Figures 25(a), 25(b), and 25(c) are block diagrams showing the potential difference and current measuring unit 200 used for potential difference measurement based on the present invention, and showing an example of a potential

15 difference and current measuring unit integrated with substrate 204 thereon. A top view of such a measuring unit is shown as Fig. 25A; a cross-sectional view of its A-A' section, as Fig. 25B; and a cross-sectional view of its B-B' section, as Fig. 25C.

20 The potential difference and current measuring unit 200 shown in Figs. 25A to 25C has a potential difference and current measuring portion formed on the substrate 204 consisting of gallium arsenic (GaAs) and other substances. Light-emitting diodes consisting of

25 n-type semiconductor area 2501 and p-type

semiconductor area 2502 are formed on substrate 204 by use of a method such as ion implantation, and this p-n junction emits light. The first insulating film 2503 is formed on the substrate including the LED forming portion, and holes 2504 and 2505 that lead to substrate 204 are provided in the n-type semiconductor area 2501 and p-type semiconductor area 2502 of the first insulating film 2503. One end of the first conductor 2506 is connected to p-type semiconductor area 2502 through hole 2505, and the other end is routed along the first insulating film 2503.

One end of antenna 203A is connected to n-type semiconductor area 2501 through hole 2504, and the other end is routed along the first insulating film 2503. The conductor antenna 203B, after being connected to the other end of the first conductor 2506, is formed on the first insulating film 2503. The second insulating film 2507 is formed on part of the other conductor antenna 203B. The second conductor 2508, after being connected to conductor antenna 203A, is formed on the second insulating film 2507. The third insulating film 2509 is formed so as to ensure that the exposed portions of the first conductor 2506, the second conductor 2508, and conductor antenna 203B are covered with the insulating film, and that the

first conductor 2506 and conductor antenna 203A are
electrically insulated. In this case, the portion
where conductor antenna 203B and the second conductor
2508 are arranged facing one another via the second

5 insulating film 2507 constitutes a capacitor, which is
connected in parallel to an LED.

According to this embodiment, since the LED emits
light according to the particular DC potential
difference between conductors antenna 203A and 203B on

10 substrate 204, the DC potential difference can be
measured by detecting the intensity of the emitted
light.

In this case, the use of a light-transmitting
substance (such as poly-silicon) to compose the second

15 conductor 2508 and the third insulating film 2509
enables light to be radiated to outside. Light can
likewise be radiated to outside by providing its
passing portion with a window that is covered with a
transparent insulating film.

20 A light-emitting diode (LED) can likewise be
formed by forming conductor antennas 203A and 203B on
silicon substrate 204, or by forming a capacitor first,
then embedding an LED microchip in the conductor
antennas 203A/203B forming area or capacitor forming

25 area by ion beam processing. Thus, a circuit of the

same composition as that described above can be formed.

Although the embodiments described heretofore are examples of measurement in a plasma etching apparatus, the present invention also enables similar measurement with a film deposition apparatus, a resist removal apparatus, and the like.

In addition, although the embodiments of semiconductor manufacturing equipment that have been described heretofore relate to a plasma source that mainly uses magnetic fields and microwaves, these embodiments can likewise be applied to other types of equipment that use a plasma source, such as equipment that uses high-frequency inductive coupling or capacitive coupling to generate plasma, or equipment that uses electromagnetic waves of the UHF band to generate plasma.

As described above, according to the present invention, it is possible to supply a potential difference and current measuring method that enables the DC potential difference on a target object to be measured using a simple means and a potential difference and current measuring portion of a simple configuration. In other words, it is possible to supply a means by which, important quantities in a semiconductor surface treatment apparatus that uses

plasma, namely, the plasma potential difference and
plasma current occurring on the surface of a wafer,
are to be measured without the modification of the
apparatus. Since the use of a camera enables non-
5   contact measurement of emitted light intensity, the
lead-in terminals for lead wires that are always
required in conventional probing methods become
unnecessary. In addition, since the target wafer does
not require lead wire connection, wafers can be
10   changed in the same way as performed for etching.

     Furthermore, according to the present invention,
it is possible to supply a highly efficient sample
processing method that uses a potential difference and
current measuring portion of a simple configuration.

15